the eggs of *Arrhenothrips* Hood enabling the emerging larvae to feed on *Arrhenothrips* eggs, but the larger number combined with the almost simultaneous emergence of *Arrhenothrips* larvae preclude its total mortality at the hands of the thrips predator[8,9]. It has also to contend with the anthocorid bug which besides feeding on all stages of the gall maker, also feeds on the eggs and larvae of *Androthrips flavipes*, incidentally enhancing the chance of survival of the former whose major females also tend to ward off the nymphs of the anthocorids. Figures 1-3 give the details regarding the eggs. Figure 4 indicates in detail, the strategies involved in the interspecific competition among the gall inhabitants of the Mimusops gall.

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VARIATION OF FREE AMINO ACIDS DURING FIGHTING IN *SCHIZODACTYLUS MONSTROSUS* DRURY (ORTHOPTERA, SCHIZODACTYLIDAE)

AMINUL ISLAM AND SUBRATA ROY
Entomology Laboratory, Zoology Department, University of Burdwan, Burdwan 713 104, India.

ENERGY metabolism in insects during various vital activities has been drawing increasing attention of the insect physiologists. Insects, in addition to sugars and lipids, use free amino acids as the readily available source of respiratory fuels[1-4]. *Schizodactylus monstrosus*, a carnivorous insect shows intraspecific aggressiveness and fighting is thus a characteristic feature of their behaviour. Most of the previous studies, on the variation of energy providing nutrients have considered the fluctuations during flight and there is no report of the patterns of energy metabolism during fighting in insects. The present paper, therefore, attempts to report the variation of free amino acids in leg muscle, fat body and haemolymph during different fighting periods.

Specimens were collected from the river basin of the Damodar and kept separately in jars, with moist sand (80% R.H.) and provided with cockroach nymphs as food. To initiate fighting, two adult males were kept in a large sized glass jars, separated into two compartments by a glass partition. This facilitated visual stimuli for the initiation of their aggressiveness. After 5 min they showed attacking tendency and were brought outside immediately to allow fighting.

Haemolymph and tissues (fat body and leg muscle) for amino acids analysis were collected at 5 min interval upto 20 min. Blood was collected by a calibrated capillary tube from the cut hind femora; dissections were performed in ringer solution. Sample preparation for amino acid analysis was done following the method of Rakshpal[5]. Qualitative separation of free amino acids was carried out by two-dimensional paper chromatography using phenol:water (5:1) and butanol:acetic acid: water (4:1:1) as the two solvents. Quantitative estimation of the respective amino acids was done as previously described[6].

Up to first 5 min of fighting in the fat body, free amino acids (FAA) showed 12.12% decline while in the haemolymph it depicted 29.73% decline. from 5-10 min of fighting, the level presented 32.22% and 25.47% decrease in the fat body and haemolymph respectively. However, the level presented 22.23% and 17.26% decline from 10-15 min of fighting in the fat body and haemolymph respectively. In the rest of the periods, the level, however, presented no significant alterations (table 1). Variation of individual amino acids showed significant utilization of proline in both fat body and haemolymph. However, the percentage of decline up to 10 min of fighting appeared high in the haemolymph in respect of the fat body. Glutamic acid after an initial decrease up to 10 min of fighting, showed 56.07% and 52.63% increased level in the fat body and haemolymph respectively. Among other free amino acid levels, serine and glycine presented slightly higher level towards the end of fighting. Methionine, histidine, alanine, arginine, leucine, aspartic acid and valine contents depicted substantial decline up to the end of fighting in both fat body showed haemolymph. Phenylalanine in the fat body showed gradual decline while in the haemolymph the rate of decline was pronounced up to 10 min of fighting Threonine in both fat body and haemolymph presented notable rate of decline up to 10 min of fighting

TABLE 1

Free amino acids content in the fat body (μg/100 mg wet wt.) and haemolymph (mg/100 ml) during different fighting periods in S. monstrosus. Data are mean ± SE (n=7)

	FAT BODY Fighting periods (min)					HAEMOLYMPH Fighting periods (min)				
Amino acids	0	5	10	15	20	0	5	10	15	20
Ala.	40 ± 3	35 ± 4	20 ± 1.9	13 ± 4	9 ± 0.6	24 ± 3	20 ± 2	14 ± 3	12 ± 3	10 ± 3
Arg.	30 ± 4	28 ± 1	12 ± 3	8 ± 0.5	3 ± 0.1	15 ± 3	10 ± 0.9	9 ± 0.7	8 ± 0.6	6 ± 0.8
Glu.	184 ± 14	145 ± 11	185 ± 13	150 ± 10	228 ± 5	90 ± 6	57 ± 4	37 ± 4	50 ± 7	63 ± 4
Asp.	114 ± 12	100 ± 11	80 ± 7	75 ± 7	75 ± 6	78 ± 5	55 ± 8	46 ± 4	32 ± 3	30 ± 4
His.	89 ± 4	78 ± 5	66 ± 7	52 ± 5	41 ± 5	67 ± 6	43 ± 5	32 ± 3	28 ± 5	27 ± 6
Gly.	174 ± 11	150 ± 9	135 ± 11	105 ± 13	128 ± 8	93 ± 6	76 ± 8	64 ± 6	62 ± 4	80 ± 7
Leu/ileu	165 ± 13	130 ± 11	110 ± 9	90 ± 11	88 ± 6	82 ± 3	67 ± 5	52 ± 6	47 ± 7	40 ± 3
Lys.	270 ± 14	220 ± 11	150 ± 9	160 ± 15	150 ± 11	150 ± 9	130 ± 10	90 ± 8	85 ± 7	84 ± 5
P.al.	430 ± 18	400 ± 14	255 ± 14	123 ± 10	80 ± 9	320 ± 12	230 ± 11	180 ± 15	145 ± 11	148 ± 9
Pro.	590 ± 17	510 ± 11	300 ± 16	210 ± 14	220 ± 12	590 ± 16	350 ± 18	240 ± 12	207 ± 11	195 ± 9
Ser.	94 ± 8	84 ± 6	65 ± 5	61 ± 7	68 ± 6	52 ± 4	45 ± 5	37 ± 6	42 ± 9	48 ± 4
Thr.	240 ± 12	170 ± 11	90 ± 8	50 ± 4	40 ± 7	130 ± 11	100 ± 8	50 ± 4	60 ± 3	62 ± 6
Val.	124 ± 12	117 ± 13	75 ± 7	60 ± 4	60 ± 5	71 ± 6	50 ± 7	35 ± 3	30 ± 7	23 ± 3
Met.	96 ± 14	94 ± 11	82 ± 8	79 ± 6	76 ± 7	66 ± 3	52 ± 4	42 ± 7	40 ± 3	35 ± 2

The variation of lysine was remarkable from 5–10 min of fighting in the fat body while the rest of the periods, the contents showed insignificant deviation in both fat body and blood (table 1).

FAA level in the leg muscle did not show profound alterations in different fighting periods. Aspartic acid, glycine, serine, valine and methionine levels declined after 10 min of fighting while their levels elevated towards the end of fighting. Proline, glutamic acid and threonine presented gradual decreasing levels throughut the periods (table 2). Fluctuation of other amino acids, however, appeared not so pronounced.

Most of the orthopteran insects are reported to derive their energy at the expences of sugars and lipids[1-3,7] Role of amino acids as the respiratory fuel has been reported in many non-orthopteran insects[4,7,8] Haemolymph FAA pool is considered as a soluble and readily available reserve for the TCA cycle, since many amino acids are metabolically degraded to acetyl CoA, pyruvic acid or TCA cycle intermediates[9-11]. The concentration of proline in both haemolymph and the fat body after different fighting periods suggests its role as an important source of energy[12-14]. From the trend of FAA utilization from the haemolymph, fat body and leg muscle, it is evident that haemolymph FAA pool serves as the main source, to be used up during the initial stages though fat body FAA reserves are metabolized to meet the energy demand in subsequent periods; FAA level in leg muscle demonstrates that in addition to the ready supply of amino acids from the haemolymph, it utilizes some of its indigenous reserves of proline, threonine and glutamic acid.

Insect fat body is reported to contain some enzymes that oxidise alanine, arginine, aspartic acid, leucine, phenylalanine and valine[9], the oxidation product of these amino acids provide glutamic acid as an intermediate product in the formation of pyruvic acid. Significant elevation of glutamic acid level towards the end of fighting supports this idea. Slight elevation of glycine and serine levels towards the end of fighting might be attributed to the conversion of threonine into glycine and serine durings its metabolic degradation to yield pyruvic acid[11] The levels of glycine, serine, valine and methionine in leg muscle demonstrate their utilization during the initial periods while in subsequent periods the increased supply of these amino acids from the haemolymph resulted slight elevation of their levels.

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TABLE 2

Free amino acids content (μg/100 mg wet wt.) in leg muscle during different fighting periods in S. monstrosus. Data are mean ±SE (n=7)

Amino acids	Fighting periods (min)				
	0	5	10	15	20
Alanine	43 ± 2	41 ± 4	33 ± 3	31 ± 6	25 ± 4
Arginine	51 ± 6	46 ± 2	47 ± 5	51 ± 3	52 ± 4
Glut. acid	190 ± 8	165 ± 7	151 ± 6	149 ± 8	141 ± 6
Asp. acid	125 ± 6	103 ± 9	105 ± 8	111 ± 6	119 ± 8
Histidine	99 ± 5	88 ± 4	90 ± 8	95 ± 4	93 ± 5
Glycine	15 ± 2	7 ± 0.6	11 ± 0.9	25 ± 3	31 ± 5
Leu/ileu	182 ± 6	191 ± 8	205 ± 11	199 ± 10	189 ± 6
Lysine	11 ± 2	5 ± 0.4	8 ± 0.5	12 ± 0.5	18 ± 0.6
Ph. alanine	451 ± 13	444 ± 16	431 ± 9	425 ± 18	419 ± 11
Proline	492 ± 11	421 ± 17	388 ± 11	361 ± 9	315 ± 12
Serine	105 ± 9	81 ± 11	62 ± 3	79 ± 5	96 ± 4
Threonine	251 ± 14	245 ± 11	221 ± 12	205 ± 9	191 ± 11
Valine	139 ± 11	127 ± 7	112 ± 9	121 ± 11	135 ± 9
Methionine	103 ± 9	89 ± 5	65 ± 4	79 ± 11	81 ± 6

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EFFECT OF SALINITY ON PROTEIN CONTENT AND SEED (SIZE OF CHICKPEA (*CICER ARIETINUM* L.)*

J. KUMAR, C. L. L. GOWDA, N. P. SAXENA, S. C. SETHI, U. SINGH AND K. L. SAHRAWAT
International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru P.O. 502 324, India.

FROM the nutrition point of view, chickpea (*Cicer arietinum* L.) is the most important pulse crop in India. It is considered to be a hardy crop and is usually grown on marginal land that often has poor soils. In several parts of India chickpea is often grown on saline soils. Salinity not only reduces crop growth severely but in extreme conditions can also lead to complete failure of the crop[1]. Little is known about the effects of salinity on the characteristics of chickpea plants grown under extremely saline conditions. This note presents data on the protein content and seed size of chickpea grown on highly saline vertisols at ICRISAT Center, Patancheru, near Hyderabad in the post-rainy seasons of 1977–78 and 1979–80. Seed weights were estimated from one sample of 100 seeds from each plot with four replications. Protein contents were determined on whole seed samples by analysing for total nitrogen using a Technicon autoanalyser[2]. Differences between mean values were compared using a 't' test.

Salinity significantly reduced 100 seed weight and per cent seed protein in each of the three sets of materials tested in 1977/78 and 1979/80 (table 1). Desi and Kabuli genotypes were similarly affected with respect to these two chracteristics although it is known that adverse soil conditions are more detrimental to kabuli than desi cultivars. The implications of the present study are very important from protein-calorie malnutrition point of view. Reduction in both protein per cent and seed size *per se* as a result of saline soil conditions will attribute to a decreased level of protein per seed and thereby the protein yield per unit area will be reduced. Also the reduced seed size will affect the consumer acceptance. These effects are also important in breeding programmes where salinity may cause unwanted variations in seed size and protein content and interfere with selection. Considering these implications and the indications that cultivaral

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TABLE 1

Mean values for 100-seed weight and protein per cent of chickpea genotypes grown in saline (S) and nonsaline (N) soils near Hyderabad, India.

Year	Desi/ Kabuli	No. of genotypes	Soil conditions	pH	EC	100 seed wt (g)	Protein (%)
1977–78	Desi	9	S	8.0	1.2–3.4	13.1 ± 0 12	12.0 ± 0.06
			N	8.2	< 0.15	21.5 ± 0.75	21.3 ± 1.79
	Kabuli	9	S	8.0	0.55–0.60	14.2 ± 0.11	12.0 ± 0.08
			N	8.2	< 0.15	22.8 ± 0.42	21.4 ± 1.89
1979–80	Desi	15	S	8.8	1.5–3.4	13.8 ± 1.29	15.3 ± 0.50
			N	8.2	< 0.20	18.3 ± 1.87	22.7 ± 0.65

[a] pH and EC (Electrical Conductivity) were measured on a soil to water ratio of 1:2.